

Field Demonstration on Rice Production, Yield, and Cost Benefit Analysis of Nerica Four (4) Variety

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Abstract: The Gambia experiences rain fed agriculture in which 70% of smallholder farmers are engaged in crops and livestock production for sustainable livelihood improvement. The production of rice for food self-sufficiency is a policy direction of the government to increase yield capacity and income of smallholder farmers in the rural communities of the Gambia. The production of rice is associated to tidal and pumps irrigation in low land alluvial soils while upland rice production depends on rain-fed agriculture. The objective of this research trial was to determine yield potentials and cost-benefits of rice production. The field experiment was designed in a randomized complete block design with different treatments and parameters. The data collected and analyzed using ANOVA and excel sheet with analysis of variances. The trial reveals that nitrogen 150kg/ha produced the highest yield of 4.96 tons/ha, whereas nitrogen zero which is control (0) kg/ha produced the lowest yield of 1.97 ton/ha while nitrogen of 100kg/ha and N50kg/ha recorded a ripening percentage ratio of 75.50% and 70.87% respectively. The trial further depicts that, the application of 50kg/ha of nitrogen provides the highest marginal rate of return making it the most cost-effective option. The application of 150kg/ha produces the highest yield and net income, it incurs higher costs and exhibits diminishing returns beyond 50kg/ha. The importance of balancing input levels with economic efficiency to optimize farmer profits. Basing on the research findings I conclude that the marginal rate of returns MRR) was determined to ascertain the financial reliability of adopting the rate of 50kg/ha as the best agricultural practice while recommending to government implement the national rice development strategy in the drive attaining rice self-sufficiency.

Keywords: Rice, production, cost-benefit, variety, analysis, demonstration.

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Introduction

The Sahelian and West African countries there is increasing demand for rice, particularly in the urban areas, that places pressure on foreign exchange for the importation of rice imports. The regional rice production based on irrigation investments has been developed to help meet consumption demand (Arouna et al; 2021). Importantly, policy makers highlighted private profitability and economic efficiency of these investments. The smallholder farmers obtained relatively low yields of 3-5 tons/ha compared to potential yields of 7-12tons/ha under irrigation (Bin and Zhang, 2023). Importantly better yields could be attained without substantial increases in cost, both profitability and efficiency

would be improved rice production and productivity. The issue of food security, poverty, and social stability are critical global priorities targeted by the United Nations' Sustainable Development Goals (SDGs) 1, 2, and 16. The achievement of these priorities is more complicated in developing countries, especially those in the sub-Saharan Africa. In 2015, about 489 million hungry people lived in post-conflict situations globally and 413 million poor people lived in Sub-Saharan Africa (SSA) with a poverty rate of 41 percent (Fuhrmann et al; 2024). The rice variety known as Nerica-4 is a widely grown, upland rice variety as part of the new rice variety for Africa (Nerica) program, and categorized for its high yield, early maturity, and tolerance to local stresses (Sutardi, 2022). It's particularly well-suited for sub-Saharan African conditions and is a major part of the region's food security.

According to (Kelly et al; 2022) Nerica rice varieties are tailored for African conditions offering high yields (2 to 6 tons per hectare), resistance to weeds, drought, and adaptability to poor soil moisture regime and conditions (Kamoga and Ssekyrewa,2021). Agronomic potential to improve yields exists, but questions remain why actual yields are low and may not be profitable for smallholder farmers. Improved crop varieties have the potential to produce higher yields than traditional varieties, but rural farmers often do not have the knowledge and skills to properly grow these crops (Saito et al; 2023). Rice as a commodity is a food security crop to meet the consumption needs of people worldwide. It is the world's most important food commodity and ranks first in The Gambia. According to empirical evidence, an average Gambian now consumes 117 kg per/head of rice per year, representing 14% of total caloric intake. The consequence of excessive importation of rice is huge as it will affect the country's foreign exchange earnings in the long run. The shift from a self-sufficient nation to an exporting nation also made rice to become a strategic commodity in the Gambia economy. The agricultural sector compensates a lion share of national income, creates employment in the rural area, foreign exchange earnings, food supply and industrial raw materials as well (Xiao et al; 2021). The process of rice production is profitable in terms of yield, revenues and price. The relationship of price and input used such as seeds, water, fertilizer, labour and management practices were the factors that significantly contributed towards output (Xiong et al; 2021). The present study focuses on the relationship of cost and revenue based on rice production in the rural communities of the Gambia.

Materials and Method

The experiment was conducted in a form randomized complete block design (RBD) with four (4) treatments and three (3) replications of twelve (12) plots. Each plot size was 12m² with a foot part of 0.5m between plots and 1m between blocks. Hot water of 60 degree Celsius soaked for disinfection which lasted for 10mins and immediately pour the rice grains in simmering water for 5mins. In addition agrochemical disinfection for 24hrs was carried out to reduce the risk of seed infections and other related diseases.

Statistical Analysis:

Generally, descriptive statistics such as mean frequency, distribution and percentage were used to describe the socioeconomic characteristics of smallholder farmers, identify their problems and addressing problems obtained from the field. Cost and return analysis was carried out to determine the profitability of rice production. This includes determination of total revenue (TR) and total variable cost (TVC) and break even analysis (BEA).

Fertilizer Application: The application of standard fertilizer (NPK) by Africa rice in the Gambia of (140kg/ha) was used to evaluate the effect of using different nitrogen application namely: 0kgN/ha; 50kgN/ha; 100kgN/ha and 150kgN/ha, while maintaining phosphorus (P) and potassium (K) at constant dosage in all treatments (100kg/ha).

Yield Components: The sampling method used was based on the hills method where in each plot 5 hills was labeled, tied up in a bundle and harvested to avoid boarder plants. The number of panicles on each hill was cut, counted, and recorded for yield analysis. The yield parameters was number of panicles per m²,

number of spikelet (grains) per panicles, percentage of ripened grains, weight of 1000 grain and yield ton/ha. The measured of variable in this research consist of farm income, R/C ratio (Return and Cost Ratio), and descriptive analysis.

Farm income analysis calculated with formula:

Farm income analysis reflects the profitability of a farm on an annual basis.

$$TC = FC + VC$$

Where: TC = Total Cost

FC = Fixed Cost

VC = Variable Cost

Results and Discussion

The production of agriculture commodities does not only serve as a result to the transformation of various inputs into outputs but subjected to the physical, natural and socioeconomic condition of the area. The production cost analysis is the process of evaluating how resources are used in production and understanding the costs incurred (Yuan et al; 2024). From the results in Table 1, shows the relationship between inputs (seeds, fertilizer and water usage) and outputs (goods or services produced) as it helps the businesses to take informed decisions about production, pricing, income, and cost reduction (Xu et al; 2021). Importantly, to increase production and productivity of agricultural commodities there is need to inject adequate resources to obtain the required yield (Saito et al; 2023).

Table 1: Shows production cost analysis.

#	Items	Unit	Quantity/kg	Values/ unit (US\$)	Value/Unit (YEN)
1.	Urea	1	20	21.32	3,200
2.	Phosphorus	1	20	17.79	2,670
3.	Potassium	1	20	23.39	3,510
4.	Water usage	-	-	213.25	32,000
5.	Insecticide	1	-	10.4	1,560
6.	Insecticide	1	-	5.33	800

The Table 2,shows nitrogen 150kg/ha produced the highest yield of 4.96 ton/ha whereas nitrogen of zero (0)kg/ha produced the lowest yield of 1.97 ton/ha. Nitrogen of 100kg/ha and nitrogen of 50kg/ha has a yield of 4.20 ton/ha and 4.14 ton/ha while control treatment (nitrogen 0 kg) obtained 1.97 ton/ha respectively. High-quality rice varieties can enhance the market status and increase rice production benefits (Odama et al., 2023). In view of rice production the application of nitrogen is an integral component of better yields as it enhances the physiology and morphological growth of plants. In this study better yields with higher nitrogen levels can be attributed to the improved availability of essential nutrients in the soil which significantly enhances better yields. These findings are consistent with those of who also observed positive and significant effects of nitrogen on yields of paddy rice (Wang et al;2023).

Table 2: Shows yield data analysis.

Treatment	Pinacles/m ²	Spikelet	Ripening ratio (%)	1000grains weight (g)	Paddy Yield (t/ha)
N150kg	250.14	93.13	77.67	28.23	4.96
N100kg	242.72	83.70	75.50	28.20	4.20
N50kg	227.93	77.36	70.87	27.52	4.14
N0kg	192.40	77.36	63.00	25.40	1.97

The result in table 3 shows the panicles per m² of 150kg/ha of nitrogen treatment scored high yields with 250.14, while zero (0) nitrogen kg/ha scored the lowest panicles per m² of 192.40 respectively. Ripening ratio of N150kg/ha recorded the highest with 77.67%, whereas zero nitrogen (0) kg/ha recorded the least percentage with 63.0%. N100kg/ha and N50kg/ha recorded a ripening ratio percentage of 75.50% and 70.87% respectively. There is a close correlation between N150kg/ha and N100kg/ha concerning 1,000 grain weight (g) which recorded a weight (g) of 28.23 and 28.20 respectively. According to other (Mumeen and Urayama, 2024) the interaction of nitrogen, phosphorus, and potassium fertilizers improved crop growth and yield, while the effectiveness of the interactions between nutrient elements depends

on their relative content in soil (Bin and Zhang, 2023). In the homogeneous groups a, b and c, there were no significant differences among the groups but within the treatments exist. Furthermore, results in Table 3 maximum 1000 grain weight was 28.23gm was obtained with 150kg/ ha of Nitrogen followed by 28.0 g of 50 kg of Nitrogen while the minimum 1000-grain weight was 25.40g was recorded for zero (control) respectively. Similar results have also been noted by (Saito et al. 2023). The increase in 1000-grain weight at higher nitrogen rates might be primarily due to the increase chlorophyll content of leaves which led to higher photosynthetic rate and ultimately plenty of assimilates available during grain development (Wang et al; 2023)

Table 3: Shows yield performance of different treatments

Treatment	Panicles per m ²	Spikelet/ panicle	Ripening/ratio (%)	1000grains weight (g)	Paddy Yield (t/ha)	Yield
N150kg	250.14 a	93.13 a	77.67 a	28.23 a	4.96 a	
N100kg	242.72 ab	83.70 b	75.50 a	28.20 a	4.20 b	
N50kg	227.93 b	77.36 b	70.87 b	27.52 ab	4.14 b	
N0kg	192.40 c	77.36 b	63.00 c	25.40 b	1.97 c	

In research economic analysis indicates the efficiency (profitability) of resources after counting all the benefits, and costs regardless of costs and benefits. Primarily, realizing a profit on the sale portion of the crop is important, but maximizing profit is not always the over-riding consideration in allocating resources (Mumeen and Urayama, 2024). The analysis in Table 4, reveals that applying 50kg/ha of nitrogen provides the highest marginal rate of return (MRR), making it the most cost-effective option. Although 150kg/ha produces the highest absolute yield and net income, it incurs higher costs and exhibits diminishing returns beyond 50kg/ha. These results show that nitrogen is the most important factor that can limit yields. It has been reported that increase fertilizer input, especially nitrogen fertilizer has significantly contributed to improvement of crop yield (Odama et al. 2023). In contrast, it has been reported that increasing levels of

nitrogen and phosphorus fertilizers favored vigorous growth of the rice, which results to competition on metabolic supply among spikelet's, thereby affecting the production of fertile grains (Arouna et al; 2021). This highlights the importance of balancing inputs levels with economic efficiency to optimize farmer profits. Increased profits increase family satisfaction only to a certain degree (Xu et al; 2021). According to empirical research profit maximization might be secondary to family satisfaction, and enterprises through productive processes that allows the family greater security and satisfaction that might take advantage over those that are more profitable. Break-even analysis is the level of a key parameters that needs to prevail for decision makers to be as well off after the change under investigation as before the change (Kelly et al; 2022).

Table 4: Cost, Revenue, Net Income, Benefit-Cost Ratio (BCR), and Marginal Rate of Return (MRR).

Nitrogen Amount	Yield	Cost(US\$)	Gross-Revenue (US\$)	Net income (US\$)	BCR	MRR
0kg/ha	1.97	1534.01	985	-549	0.64	None
50kg/ha	4.14	1587.31	2070	483	1.30	1947.20
100kg/ha	4.2	1640.61	2100	459	1.28	-44.40
150kg/ha	4.96	1693.91	2480	786	1.46	617.00

The graphical representative in figure 1, shows total revenue of all factors include amount of sales of harvest and all that consumed by family farmers (Bin and Zhang 2023). The average production per hectare calculate by production (kg) multiple with price of grain at harvest while the total revenue (TR) shows the income received from the sale of products. Furthermore, the break-even analysis shows neither profit nor loss where yield, price and income determines the profitability of a business entity (Wang at

el; 2023). The marginal rate of returns MRR) was determined to ascertain the financial reliability of adopting the rate of 50kg/ha as the best agricultural practice. The result of the study showed that adopting the rate of 50kg/ha has huge financial benefit or revenue base of 2070 US\$. However, the total fixed cost (TFC) remains constant and there was no depreciation cost at the time of the trial demonstration.

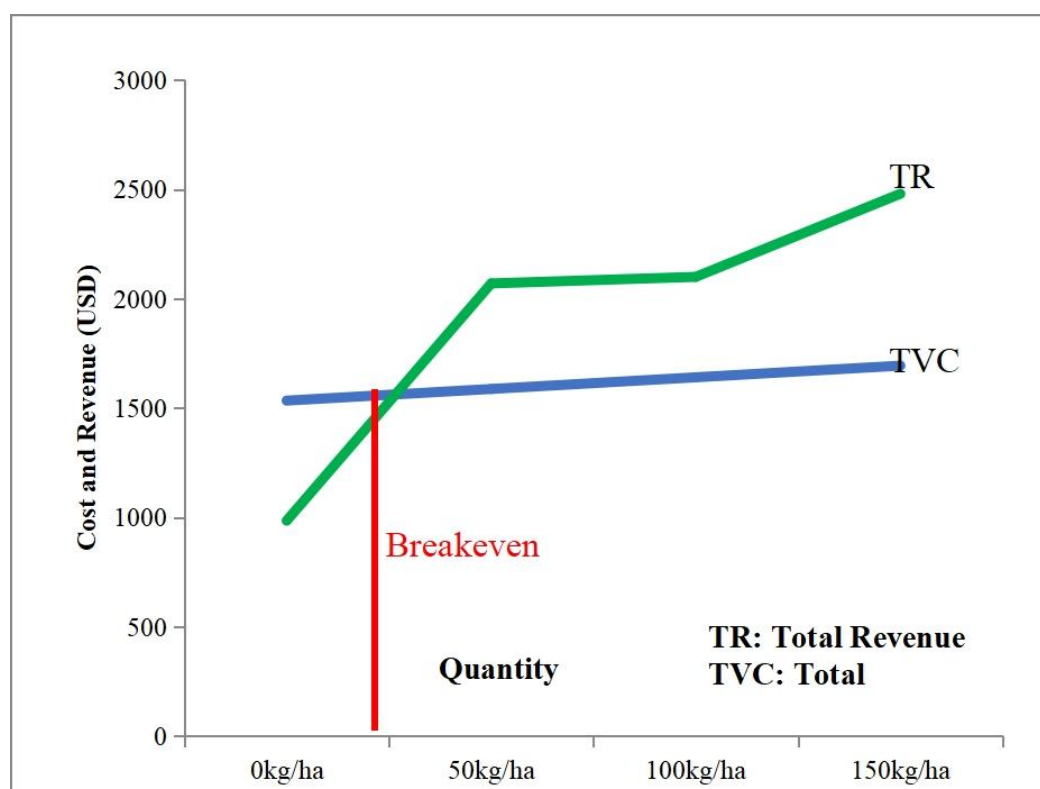


Figure 1. Shows production cost and profitability analysis.

Conclusion and Recommendation

The agricultural systems of the Gambia highly depends on rain-fed farming across the country with few pockets of tidal and pump irrigation in Central River Region and Upper River Region respectively. There are three (3) agro-ecological environment suitable for rice production in the rural communities that is up-land, low land and hydro-homophobic soil conditions. The government initiated key policies, programme and strategies to serve as catalyst to boost rice self sufficiency of small holder farmers. The objective of this research trial was to determine yield

potentials and cost-benefits of rice production. The experiment was conducted in a form randomized complete block design (RBD) with four (4) treatments and three (3) replications of twelve (12) plots. Each plot size was 12m² with a foot part of 0.5m between plots and 1m between blocks. Generally, descriptive statistics such as mean frequency, distribution and percentage were used to describe the socioeconomic characteristics of smallholder farmers, identify their problems and addressing problems obtained from the field. The nitrogen application of 100kg/ha and nitrogen of 50kg/ha has a yield of 4.20 ton/ha and 4.14 ton/ha while control treatment (nitrogen 0 kg) obtained 1.97 ton/ha respectively. Basing on the

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